Fertilizer performance of organic fertilizers as compared to synthetic fertilizer: a laboratory and a field scale assessment in Croatia

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INTRODUCTION

- Anaerobic digestion (AD) is a recognized technology for the processing of organic waste. In Croatia, however, AD sector is only starting to emerge.
- Important challenges in the biogas (direct digestate producers) and agricultural (potential digestate users) sector in Croatia deal, nowadays, with the lack of knowledge on chemical composition and fertilizer performance of digestate.
- As a consequence, digestate has no market value in Croatia and the legislative framework is still not defined.
- The aim of this study was to determine and showcase nitrogen (N) performance of digestate as compared to synthetic N fertilizer by i) assessing N availability and dynamics in controlled conditions via laboratory incubation, and ii) determining fertilizer performance of digestate derivatives in a full-scale maize production by comparing maize yield.

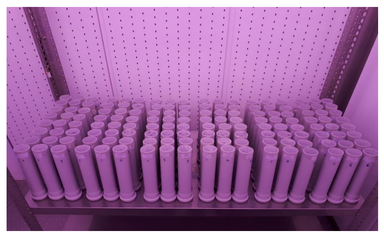

Figure 1. Incubation experiment

Figure 2. Field experiment

MATERIALS AND METHODS

1. LAB SCALE ASSESSMENT

- The following treatments were tested (n=3): i) control (unfertilized), ii) synthetic N fertilizer (NPK of 15% N and CAN of 27% N in ratio 50:50), iii) liquid fraction of digestate (LFD; 3.3 g N kg^{-1}), iv) solid fraction of digestate (SFD; 6.2 g N kg^{-1}), v) liquid cattle manure (LCM; 3.1 g N kg^{-1}), vi) LFD + NPK, vii) SFD + NPK and viii) LFD + SFD.
- Fertilizers were mixed homogenously with soil, filled in PVC tubes, and kept at 18°C and 50% water filled pore space (WFPS) for 120 days. The application rate was 140 kg N ha^{-1}.
- Every 20 days destructive sampling was done to determine the mineral N in treatments.

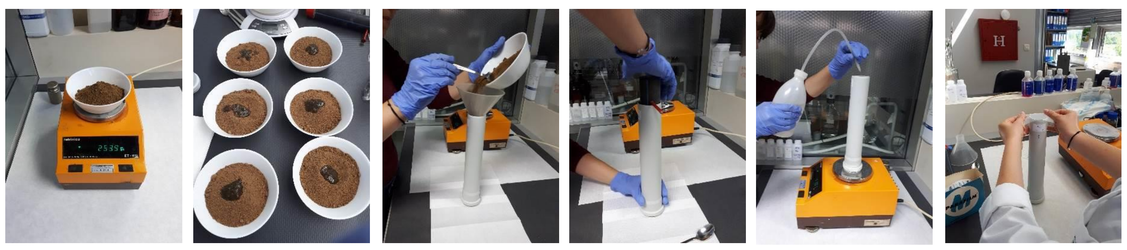

Figure 3. Incubation experiment

- After analysis both the net N release (N_{rel},net) from the added materials and the net N mineralization ($N_{min,net}$) were calculated with the following equations:

$$N_{rel,net}\,(\%) = \frac{([NO3^{-}\text{–}N,treatment]-[NO3^{-}\text{–}N,control])+([NH4^{+}\text{–}N,treatment]-[NH4^{+}\text{–}N,control])}{Ntotal\ applied} \text{ x } 100$$

$$N_{min,net}\,(t;\ \%\ total\ N) = (N_{rel,net}\,(t) - N_{rel,net}\,(t=0))$$

2. FIELD SCALE ASSESSMENT

- The same eight treatments (n=4), as in the lab assessment, were applied on a silt loam soil located in Maksimir (Zagreb).
- Due to nutrient variability and time difference in sampling moments, LCM, SFD and LFD contained 4,1 g N kg^{-1} 12,7 g N kg^{-1} 8,1 g N kg^{-1}, respectively, at the moment of fertilization (Figure 4).
- As a test crop, maize was sown on April 27 and harvested on September 28, 2018.

Figure 4. Fertilization moment on April 27, 2018 and maize during growing period

RESULTS

- Results showed that the release of N highly depends on the material that was added to soil while mineralization only occurred in bio-based materials that contained organic N.
- Error bars indicate standard deviations (n=3) and the value of N release, on average scale after 120 days of incubation experiment was in the order: NPK+CAN > LFD+NPK > SFD+NPK > LFD > SFD+LFD > LCM > SFD (Figure 5). Value plotted at t=0 indicates the percentage of mineral N in applied material and is presented with a straight line over the graph throughout 120 days of incubation time.

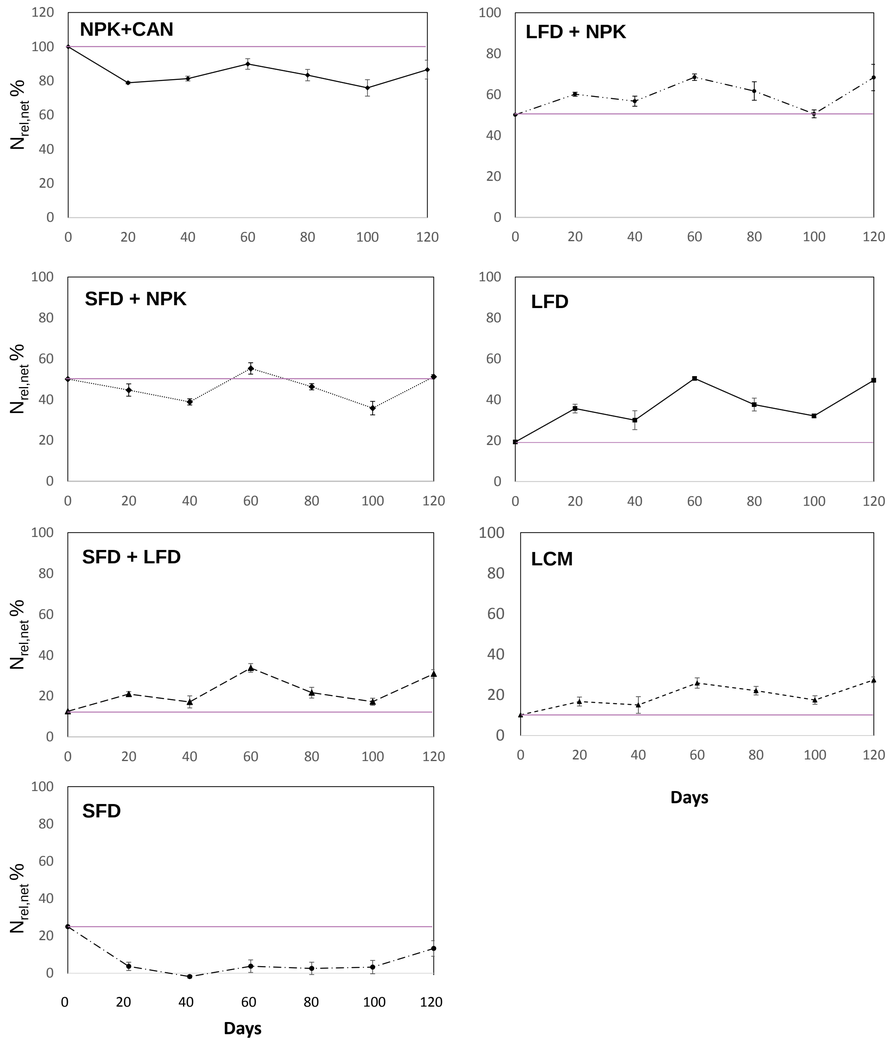

Figure 5. N release ($N_{rel,net}$; %) relative to the N input of added materials in 120-day incubation experiment.

- The $N_{min,net}$ (expressed as % of organic N applied) from amended treatments on day 120 was 0%, -6%, 9% 10%, 13%, 16% and 33% for NPK+CAN, SFD+NPK, LFD+NPK, LCM, SFD, SFD+LFD, LFD, respectively (graph not shown).
- Obviously, the amount of applied organic N differed greatly between tested materials and was mostly low, which lead to large variabilities in the estimation of $N_{min,net}$ data.

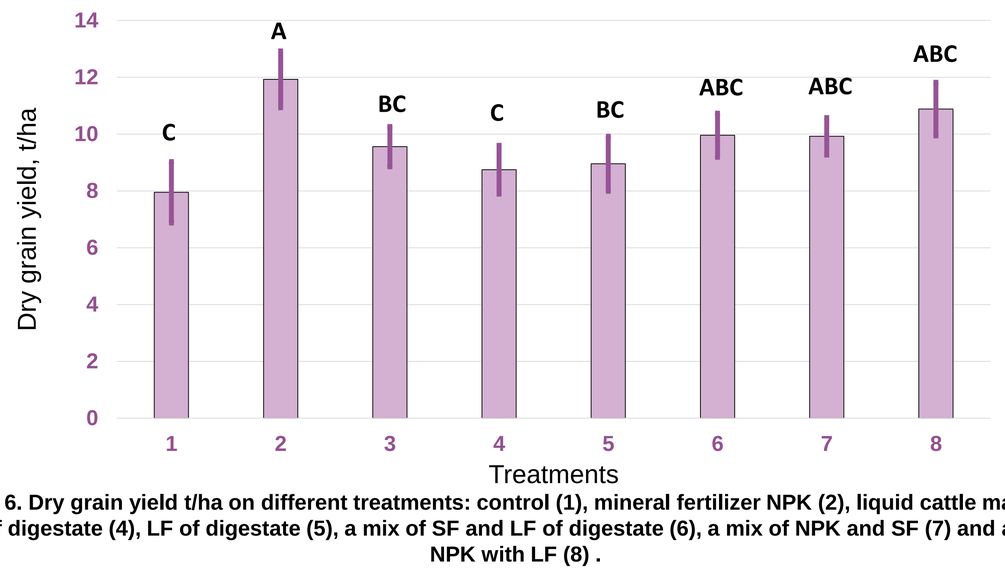

Figure 6. Dry grain yield t/ha on different treatments: control (1), mineral fertilizer NPK (2), liquid cattle manure (3), SF of digestate (4), LF of digestate (5), a mix of SF and LF of digestate (6), a mix of NPK and SF (7) and a mix of NPK with LF (8) .

- Results showed that NPK+CAN, a mix of SFD+LFD, a mix of SFD+NPK and a mix of LFD+NPK resulted in a higher yield as compared to other treatments (Figure 6.).

CONCLUSION

- The mixture of digestate with NPK resulted in a grain yield similar to the application with the synthetic NPK fertilizer. This shows that in short-term digestate derivatievs had a similar effect on maize production. This might lead to cost reduction of used synthetic fertilizer on arable land.
- Digestate fractions (solid and liquid) showed positive effect as soil improver. Therefore, bio-fertilizers can present an attractive and sustainable alternative to synthetic fertilizers in Croatia.
- Digestate will be further investigated.

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